

Appn. No. 09/986,712
Amdt. dated November 21, 2003
Reply to Office Action of August 22, 2003

PATENT

REMARKS/ARGUMENTS

Claim 10 has been cancelled and the subject matter of claim 10 has been introduced into claim 1. Claim 11 and 12 have been amended to be dependent to Claim 1. Claim 17 has been amended to overcome the Examiner's rejection. No new subject matter has been added.

The Examiner has rejected Claims 1 and 3 - 17 under 35 U.S.C 102(e) as being anticipated by Sun et al. (US 6,517,238). Sun et al. discloses a system and method to measure the lateral thermal diffusivity for a material under test, which is a thermal property manifested by the speed at which heat is transferred in a perpendicular direction within the material relative to the direction from which the heat has been applied. By exhaustively analyzing this diffusivity on each pixel of the thermal image of the sample material, Sun et al. claims its system may detect cracks perpendicular to the heated surface within the material.

The Sun et al. measurement system teaches an infrared inspection technique using a mathematical model to determine the lateral thermal diffusivity of a sample material. In its operation, the pulsed heat energy is injected from the back side of the sample and an interface is determined at the sample's back surface by partially shielding the sample to prevent a portion from being heated directly by the pulsed heat energy. An interface is thus defined along the edge between a shielded portion and the unshielded portion on the back side of the tested sample. An infrared ("IR") camera captures a series of thermal images from the front side of the sample to detect and record the temperature distribution of the thermal diffusivity which is conveyed through the thickness of the tested object perpendicular to the pulsed heat injected from the back side of the sample ("through-thickness diffusivity"). The interface as well as the recorded through-thickness diffusivity and other previously measured parameters, such as sample thickness and sample width, are applied to a theoretical mathematical model of the heat transfer process to determine the experimental lateral thermal diffusivity at the defined interface. A comparison between the measured lateral thermal diffusivity and the corresponding theoretical counterpart for that sample material is made, and the difference may indicate the location of possible cracks within the tested sample.

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The prior art inspection system has been applied on some sample materials such as a ceramic composite and a aluminum alloy, wherein the tested object has substantially homogenous thermal properties which may be analyzed using a mathematical model. This system is impractical if not inapplicable when the objective of the inspection is more than for the detection of cracks within a bulk material, such as a mass of aluminum alloy. Detecting the possible defects around the very fine connections and junctions comprising heterogeneous components, for example, copper pads, balls and solder junctions of a ball-grid array on a populated circuit board having finer pitch over increasing complexity by using the method and system disclosed in Sun et al. is simply impossible.

The present invention teaches a method and system using thermography according to a comparison approach for detection of defects on a populated printed circuit board ("PCB"), whereby the method directly compares the captured thermal image to a set of thermal images of a known defect-free PCB board in order to evaluate the quality of the connections and junctions on the tested board. The claimed system does not rely on any analysis related to the lateral thermal diffusivity nor on a means operative to measure such a thermal property recited in Sun et al. reference. The claimed system directly captures the temperature distributions of the thermal diffusivity which is transmitted therethrough and diffused throughout all the PCB material, including its copper layers, traces, pads, junctions and mounted devices on a populated board from pulsed heat injected from the back side of the board (so-called transmissive diffusivity). A comparison of the captured transmissive diffusivity between an populated board and known defect-free populated board as well as the resultant differences is expected to indicate possible defects occurring in the tested board including very likely defects around the junctions and connections between numerous different components. The present invention relies on and is limited to the availability of at least one known reference which is essentially defect-free, rather than based on a theoretical model of a thermal process inherent in the object. The present invention provides an experimental evaluation which is easily applied to very fine component parts, such as the substantially numerous and heterogeneous components composed on a populated board, wherein the components may be too small or too closely adjacent to the

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neighbors to be analyzed according to the measurement system disclosed by Sun et al., and where the thermal properties are too complicated to fit a theoretical model.

Among the cited but unapplied references, Bruce et al. (US Pat. 6,146,014) discloses methods for analyzing temperature characteristics of an integrated circuit using a comparison approach in reference and likewise an application similar to the present invention. In one embodiment, a beam of laser light is directed at the back side of an integrated circuit. The method measures the intensity level of laser light reflected from the integrated circuit and compares the measured intensity level to a reference intensity level. According to Bruce et al., the temperature characteristic of the tested object is analyzed by measuring the difference between the reference intensity level and the intensity level of the reflected laser light. Completely in a contrast, the present invention injects laser light pulses at the bottom surface of a tested board, then records the heat diffusion throughout the board by an IR camera.. The present invention compares the heat diffusion over time at a specific point of the board to a reference to detect any defects of inspected board. Although Bruce et al. teaches to detect the defect analysis of a semiconductor circuit using a laser light, Bruce et al. merely teaches a method to detect defects based on the intensity of the reflected light, rather than on transmissive diffusion captured by an IR camera.

Claim 1 now recites a method for inspecting on a populated board with the noted feature. Claim 17 has also been amended to overcome the Examiner's rejection under 35 U.S.C. 102(e) as being anticipated by Sun et al. Claim 17 now recites an apparatus for inspecting a populated board and detecting defects. Sun et al. does not teach the method as now claimed by claim 1 nor the apparatus as now claimed by claim 17. Claim 3 - 16 depending on the amended claim 1 and claim 18 - 24 depending the amended claim 17 should be allowable accordingly.

CONCLUSION

In view of the foregoing, Applicants believe all claims now pending in this Application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

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If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 650-326-2400.

Respectfully submitted,



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